City of Phoenix

2005 Greenhouse Gas Emissions Inventory for Government Operations

August 2009

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Acronyms

CACP 2009	Clean Air and Climate Protection 2009 Software
CARB	California Air Resources Board
CCAR	California Climate Action Registry
CH_4	Methane
CNG	Compressed Natural Gas
CO_2	Carbon Dioxide
CO_2e	Carbon Dioxide Equivalent Emissions
EPA	Environmental Protection Agency
GHG	Greenhouse Gas
GWP	Global Warming Potential
IPCC	Intergovernmental Panel on Climate Change
JPA	Joint Powers Authority
LandGEM	Landfill Gas Emissions Model
LGOP	Local Government Operations Protocol
LNG	Liquid Natural Gas
LPG	Liquefied Petroleum Gas
N_2O	Nitrous Oxide

1. Overview

In January 2008, the City of Phoenix began a project to conduct an inventory of greenhouse gas (GHG) emissions resulting from government operations, develop a forecast of emissions for a future year, and prepare a Climate Action Plan to reduce greenhouse gas emissions. This effort is part of long tradition of environmental and sustainability efforts by the city. A summary of the current and complimentary sustainability programs can be found on the city's web page at http//Phoenix.gov/sustainability.

This report details the GHG emissions inventory for the year 2005 from the Phoenix government operations and estimates the future emissions for 2015. This emissions inventory report provides the technical support for the *City of Phoenix Climate Action Plan for Government Operations.* This inventory is compliant with the principles of the 2008 *Local Government Operations Protocol (LGOP)*, the standard for local government GHG accounting. The inventory is organized by sectors that reflect the city operations:

- Buildings and Other Facilities
- Vehicles
- Solid Waste
- Employee Commute
- Wastewater Treatment (WWT)

Creating this inventory involved collecting and reviewing extensive records on building electricity and natural gas use, methane generation from landfills and WWT, vehicle fuel consumption, and other sources of emissions in government operations. City of Phoenix staff provided the data used as the basis for the GHG calculations. A summary of all the data used in this inventory is found in the *City of Phoenix 2005 Emissions Inventory Summary Workbook* (Emissions Summary Workbook). Additional information on the *Emissions Summary Workbook* and the supporting documents is included in Appendix A.

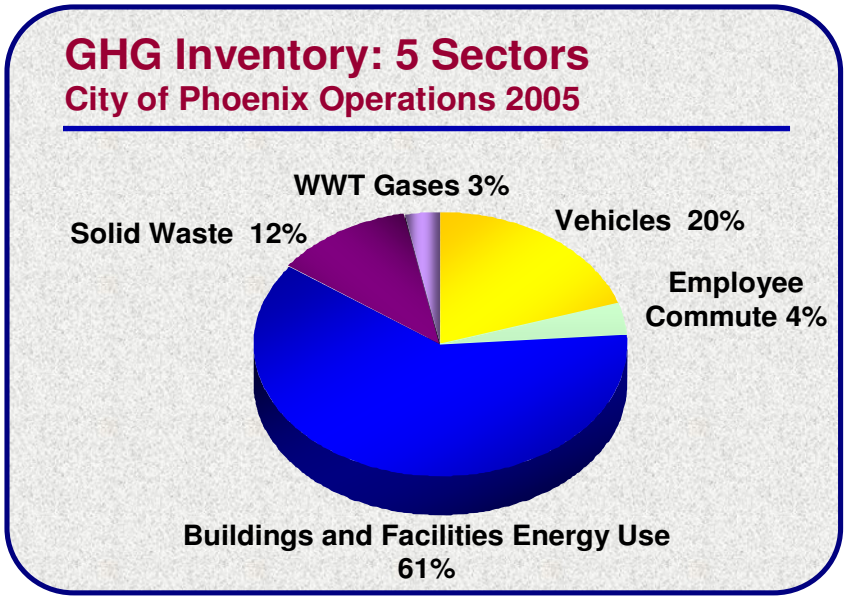
In this report, GHG emissions are reported as carbon dioxide equivalent (CO_2e) metric tons to be consistent with the established international standard for comparison of the global warming potential (GWP) of different GHG relative to CO_2. For example, the Intergovernmental Panel on Climate Change (IPCC) indicates that methane (CH_4) is 21 times more potent than CO_2 and nitrous oxide (N_20) is 310 times more potent in heat trapping potential. Based on these GWP equivalents, one metric ton of CH_4 is reported as 21 metric tons CO_2e and one metric ton of N_20 is reported as 310 metric tons CO_2e.

2005 Emissions

The city selected 2005 as the baseline year because records for that time period provide the most reliable data which can be replicated in future years to allow accurate comparisons.

The inventory found that the total GHG emissions from municipal operations were 618,682 metric tons CO_2e in 2005. Figure 1 shows the relative emissions from each sector.

Figure 1. GHG Emissions Inventory by Sector



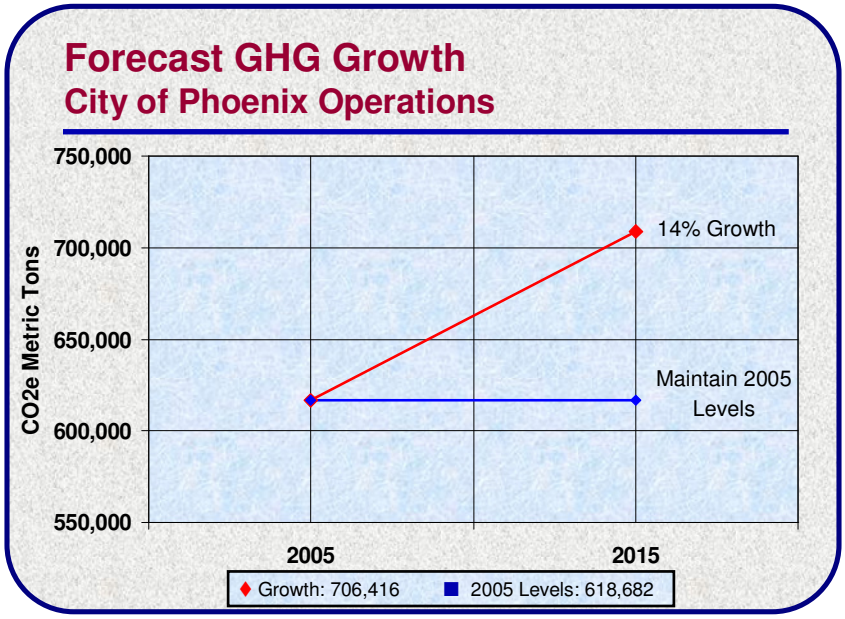
The greatest source of GHG emissions in city operations was energy used in the Buildings and Other Facilities sector which contributed 61 percent of the total. This includes electricity and natural gas energy used in all buildings, parks, street lighting, traffic signals, water distribution, water treatment, and other facilities. Fuel use in the city fleet was contributed 20 percent and employee commute was responsible for 4 percent. Emissions from WWT processes contributed 3 percent while methane emissions from landfills contributed 12 percent.

2015 Growth Forecast

Phoenix selected 2015 as the best option for projecting future growth. Beyond 2015, city departments were much less confident in estimating energy needs for potential new regulations, population growth, and other key factors.

As shown in Figure 2, the GHG emissions are forecast to increase to 706,416 metric tons CO2e between 2005 and 2015 under a No Action scenario. This represents a growth of 14 percent over the 10 year period. To achieve emissions below the 2005 levels, the city will first need to overcome this increase.

Figure 2. Growth in GHG Emissions



Comparison to Other Cities

It is important to recognize that it is difficult to compare the GHG emissions from the City of Phoenix government operations to other cities. Any comparison is likely to be deceiving because each jurisdiction has unique operations and their emissions inventory will include different sources. This is especially true for emission inventories that are not compliant with the Local Government Operations Protocol (LGOP) accounting principles discussed in Section 2. In addition, emission inventories conducted in other cities may not include sources such as employee commute, emissions from WWT processes, airport operations, landfills, or other sources. Any attempt to compare Phoenix's inventory to another jurisdiction should include a thorough understanding of the differences between the operations included in the inventory and the accounting methods used.

2. Local Government Operations Protocol

This inventory is one of the first to be developed using the Local Government Operations Protocol (LGOP), a new national standard developed and adopted by ICLEI, the Climate Registry, California Air Resources Board, and the California Climate Action Registry. First published in September 2008, this standard is an accounting framework designed to help local governments in the U.S. prepare and report emission inventories in a consistent way. It provides accounting boundaries, quantification methods, and reporting procedures for calculating GHG emissions from local government operations. The accounting principles are based on the World Resources Institute GHG Protocol.

Organizational Boundary

According to the protocol, a local government must choose between two options under the organizational boundary: operational control and financial control. An inventory based on operational control includes GHG emissions from government operations that are *controlled* by the local government, regardless of whether or not the city owns those operations. Under the financial control approach, emissions from operations are allocated among parties that have a financial stake in the operation. The Phoenix 2005 inventory follows operational control because this more accurately represents the sources in the city operations.

Under the operational control approach, the city evaluated the option to include the 91st Avenue WWT plant. This plant accepts wastewater from several other cities and is operated under a formal Joint Powers Authority (JPA) agreement. Although the LGOP accounting system recommends that JPA's be excluded from the inventory, the emissions from this facility have been included because Phoenix operates the facility and is listed on the facilities air and water permits. This approach may be subject to change in the future if other partners in the facility develop their own greenhouse gas emissions inventories and wish to include their share of the emissions from the facility.

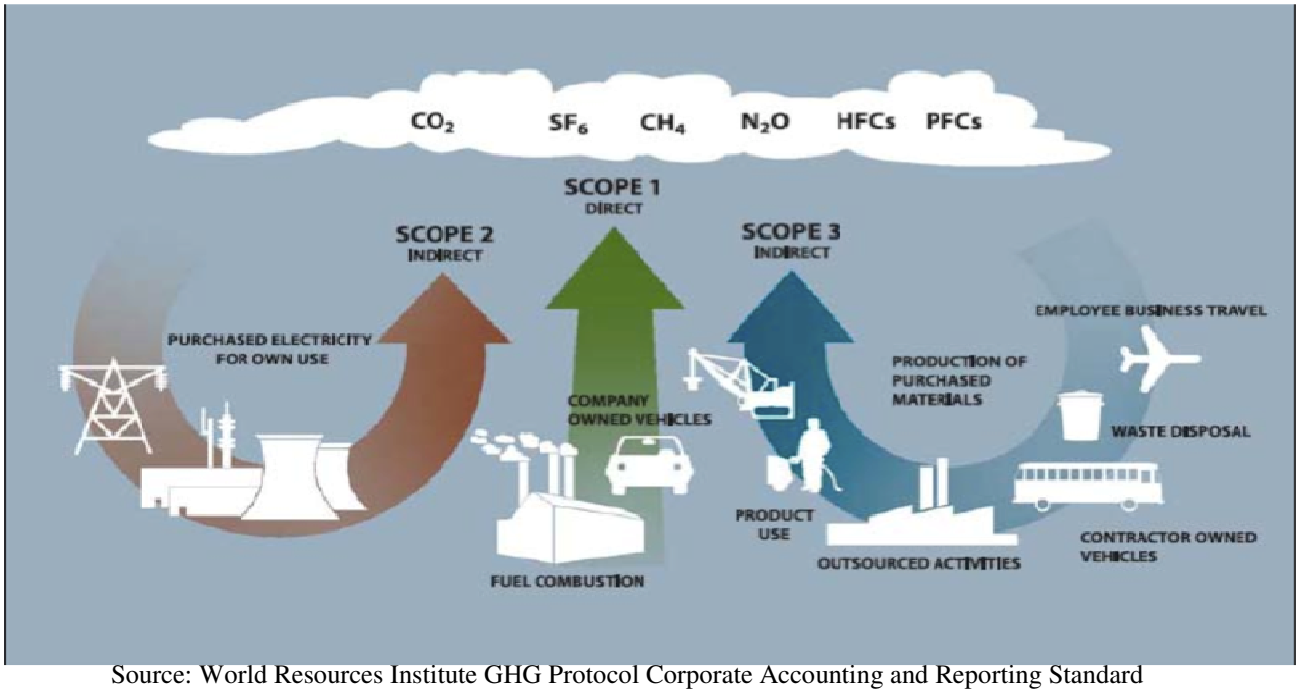
The city also reviewed options for including the facilities that are owned by the city but leased to other entities. Consistent with the operational control approach in the protocol, this emissions inventory generally does not include energy used at city-owned leased facilities. For example, the energy use at the city's public housing buildings is not included because the housing units are leased to tenants. In addition, the Consolidated Rental Car facility at Sky Harbor International Airport is excluded because the space in the facility is leased to private rental car companies.

A somewhat unique circumstance for emissions from leased facilities is the Phoenix Sky Harbor International Airport. The airport could have been excluded under this operational control approach because the facilities are leased to tenants (airlines, restaurants, gift shops, etc.). All the cost of the energy used at the airport is allocated to tenants based upon the size of the revenue generating area. However, Phoenix chose to include the emissions from the airport facilities because city's Aviation Department has more than 800 employees at the airport who provide administration and operational services.

Operational Boundary

In addition to deciding the organization boundary, the LGOP accounting system requires cities to define the operational boundary for direct and indirect emissions. Direct emissions include emissions created on-site by city operations. Indirect emissions are those generated in the production of energy or products used in the city operations. As shown in Figure 3, the protocol groups the direct and indirect emissions into three "scopes".

Figure 3 – Emissions Scopes



Source: World Resources Institute GHG Protocol Corporate Accounting and Reporting Standard (Revised Edition), Section 4.

The three scopes are defined below.

- **Scope 1:** Direct emissions which come from city operations. Examples include fuel consumption by the city fleet, natural gas burned in boilers, and gases from landfills and WWT plants.

- **Scope 2:** Indirect emissions generated by utility companies based on the electricity purchased for municipal operations.

- **Scope 3:** Indirect emissions generated from contracted services, production of products and materials, and other outsourced activities. Under the LGOP accounting system, a local government generally has the option to include Scope 3 emissions based upon data availability, the ability to impact emissions reductions, and other considerations. Employee commute emissions are included in Scope 3, but the protocol requires that these emissions be included in the inventory because there is a greater potential to impact these emissions through rideshare incentives and other programs.

A complete accounting of emissions by scope can be found in Appendix B.

Emissions Inventory Results

The results of the emissions inventory are detailed in the Sections 3 through 7 in this report. The sections are arranged according to their contribution to the GHG emissions.

3: Buildings and Other Facilities
4: Vehicles
5: Solid Waste
6: Employee Commute
7: Wastewater Treatment

3. Buildings and Other Facilities

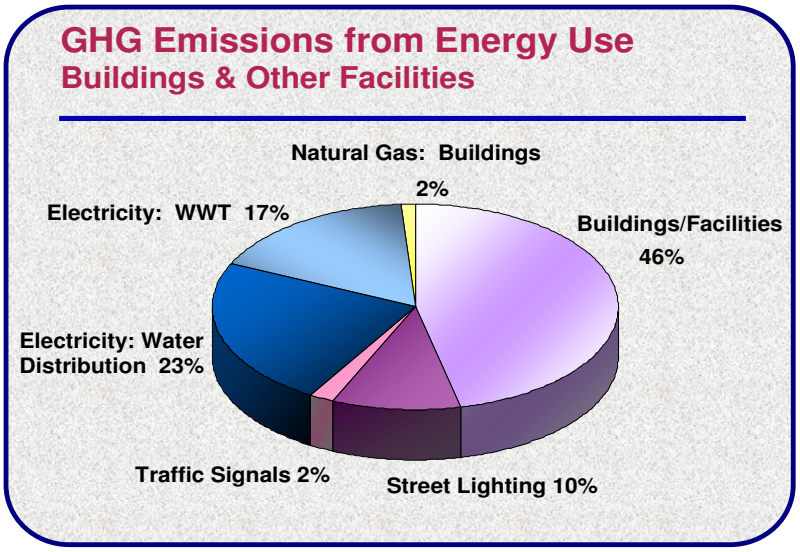
The Buildings and Other Facilities sector includes electricity and natural gas used for buildings, street lighting, traffic signals, parks, WWT, drinking water treatment, and other stationary sources.

Electrical and natural gas energy used in municipal operations support a full range of services. The City of Phoenix serves a population of more than 1.5 million residents within a 517 square mile area. The city operates approximately 1,500 buildings, 600 recreational amenities/facilities, and maintains more than 5,000 miles of streets with approximately 1,064 signalized intersections and 92,500 streetlights. The Water Services Department serves more than 410,000 water customer connections, provides more than 119 billion gallons of potable water each year, and treats more than 183 million gallons/day of wastewater.

2005 Emissions

Overall, this sector generated GHG emissions of approximately 376,686 metric tons CO_2e in 2005, or 61 percent of total emissions for city operations. The chart below (Figure 4) shows the breakdowns within the sector. Of the total 376,686 metric tons CO_2e, approximately 46 percent was attributable to electricity use in buildings and facilities, 23 percent from electricity used for drinking water distribution, 17 percent from electricity used in WWT, 2 percent from natural gas use, 10 percent from street lighting, and 2 percent from traffic signals.

Figure 4: GHG Emissions from Energy Use



The electricity and natural gas use for each category and the associated emissions are shown in Table 1.

Table 1: ENERGY USE IN BUILDINGS AND OTHER FACILITIES

Energy Use Area	Electricity KWh	Natural Gas Therms	Emissions 2005 (CO_2e metric tons)
Electricity: Buildings & Facilities	307,081,796		176,426
Electricity: Street Lights	64,485,926		36,828
Electricity: Traffic Signals	12,951,310		7,396
Electricity: Water Treatment & Distribution	148,849,747		85,007
Electricity: Wastewater Treatment	111,371,982		63,604
Natural Gas: Buildings. & Facilities		1,202,280	6,397
Natural Gas: Water Treatment & Distribution		18,304	98
Natural Gas: Wastewater Treatment		173,290	930
Total	**644,740,761**	**1,393,874**	**376,686**

The Emissions Summary Workbook that supports this report includes more detailed information on energy use by each department. Appendix A provides a summary of the information available in the workbook.

2015 Growth Forecast

Emissions from this sector are forecast under a No Action scenario to grow to 444,291 metric tons CO_2e by 2015. This 67,605 ton increase represents an 18 percent increase over 2005 levels.

The 2015 emissions number assumes that energy used in most city buildings will increase approximately 1 percent per year, compounded over the 10 year period. This number is based a review of recent energy data and has been used by used by the Public Works Department Energy Manager for calculating the impact of energy conservation projects.

An annual growth rate of 1.5 percent is used for the Water Services Department because the energy needed for distribution and treatment facilities is expected to increase more rapidly than the other city facilities. The anticipated additional energy would be required to operate new equipment that may be necessary to meet new or emerging federal regulations. The GHG growth is based on Water Services Department estimate that approximately 20,371,000 kWh of electricity and 1,500,000 therms of natural gas will be consumed by new projects scheduled to come online by 2015.

4. Vehicles

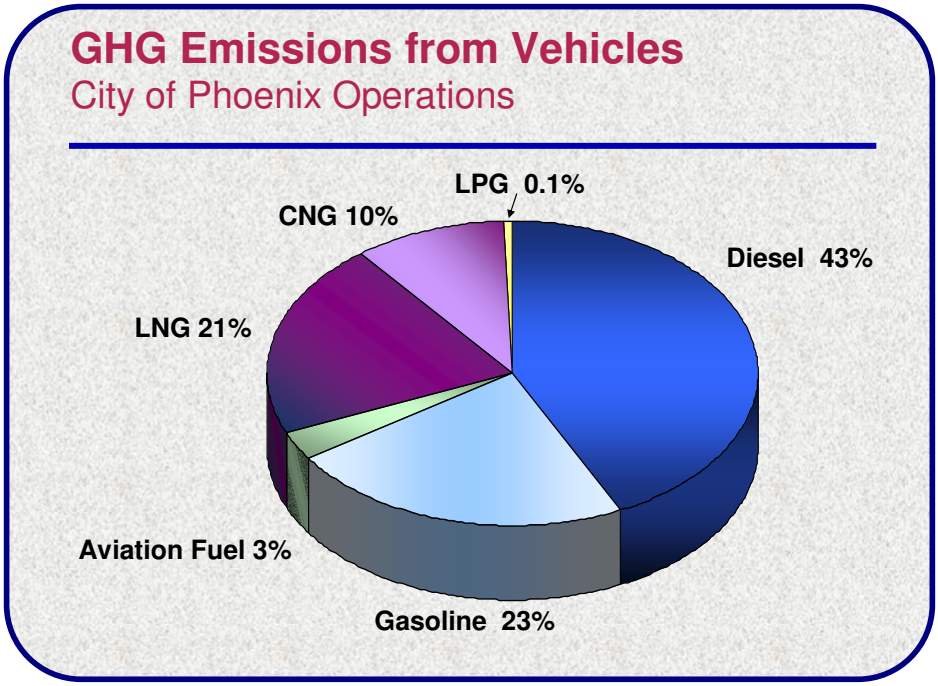
The GHG emissions from the Vehicle sector is based on the fuel use data for the city fleet including gasoline, diesel, compressed natural gas (CNG), liquid natural gas (LNG), liquefied petroleum gas (LPG), aviation gas and jet fuel used in Police Department aircraft.

The municipal fleet is comprised of more than 7,300 vehicles. The majority of the fleet is maintained by the Public Works Department, with Public Transit and Aviation departments managing their own fleets. The Phoenix alternative fuel program is one of the largest in the nation with approximately 2,900 alternative-fuel vehicles using more than 12.1 million gallons of alternative/clean fuel in fiscal year 2008/09.

2005 Emissions

The Vehicles sector had emissions of approximately 122,141 metric tons CO_2e in 2005, or 20 percent of total emissions from city operations. Figure 5 shows the contribution from each of the fuel types within this sector.

Figure 5: GHG Emissions from Vehicles



Of the total emission in this sector, 23 percent were attributable to gasoline use, 43 percent from diesel, 10 percent from CNG, 21 percent from LNG use in the transit fleet, and 3 percent from aviation gasoline and jet fuel (listed as "other" in the table below). The LPG fuel was generally used only in forklifts represents only 91 metric tons CO_2e or 0.1 percent. Table 2 shows the volume of fuel used and the associated emissions.

Table 2: VEHICLE FUEL USE BY FUEL TYPE

Fuel Type	Fuel Used	Units	Emissions 2005 (CO_2e metric tons)
Gasoline	3,172,441	gallons	28,683
Diesel	5,452,613	gallons	52,376
CNG	1,744,813	gallon equivalent	12,610
LPG	14,392	gallons	91
LNG	7,917,008	gallons	25,141
Other	165,561	gallons	3,240
Total	**18,466,828**		**122,141**

Additional detail on fuel consumption data for each department is included in the *Emissions Summary Workbook* that supports this report.

2015 Growth Forecast

Emissions from this sector are forecast to grow from 122,141 in 2005 to 154,288 metric tons of CO_2e by 2015. This growth of 32,148 metric tons represents an increase of 20 percent over 2005 levels. The Public Works Department reported that the overall fuel use in the city fleet is expected to increase at a rate of 2 percent per year. This estimate is based upon the historic records on the city's fuel consumption. The growth rate for fuel used in the transit buses is forecasted to increase 1 percent annually because expanded light rail service will reduce the rate of growth in new bus routes.

5. Solid Waste

This sector includes emissions from methane generated from decomposing waste in landfills owned by the city. The emissions associated with energy used to operate the landfills are accounted for in the Buildings and Other Facilities sector (Section 3). Fuels used to transport solid waste are included in the Vehicles sector (Section 4).

The City of Phoenix provides solid waste collection for more than 390,000 residential customers and disposed of approximately 1,000,000 tons of waste in Fiscal Year 2008/09. The waste is sorted at two transfer stations and transported to the State Route 85 (SR-85) landfill which opened early in 2006. Phoenix also maintains five closed landfills: Skunk Creek, 27th Avenue, Del Rio, 19th Avenue, and Deer Valley. These landfills all have methane collection and treatment systems.

The city also owns several smaller landfills that have been acquired for Rio Salado Wetlands, river bank protection at the airport, and other projects. These landfills were not included in the inventory because they were not operated by the city, and they are generally old, small facilities that are not expected to have significant emissions. In addition, data on the waste volumes and types is not adequate to estimate emissions. The exclusion of these landfills is consistent with the Mandatory GHG Reporting Rule adopted by EPA in September 2009. This rule exempts landfills that were closed before 1980 based on the age, anticipated low emissions, and lack of available data.

The solid waste from commercial, industrial, and multi-family sources is not included in this inventory because collection and disposal services are conducted by private companies that are not associated with the city.

Phoenix operates a voluntary recycling program available to single family homes. More than 120,000 tons of recyclable materials are collected each year. The city also has contracts for mulching services which diverts approximately 20,000 tons of green waste from the landfill each year.

2005 Emissions

The emissions inventory found that the six landfills operated by the city produced emissions of approximately 76,537 metric tons CO2e in 2005, or 12 percent of total GHG emissions from city operations. Table 3 shows the 2005 emissions from each landfill included in this sector. The SR-85 landfill is included in the list, but the emissions are not listed because the landfill was not open in the 2005 baseline year.

Table 3: SOLID WASTE EMISSIONS BY LANDFILL					
	METHANE PRODUCTION				GHG EMISSIONS
Landfill	Methane Production (2005)	Units: Metric	Methane Capture Rate	Net Release (2005)	2005 CO_2e metric tons*
Skunk Creek	5,309	tons	50%	2,389	50,156
27th Avenue	6,438	tons	85%	869	18,253
Del Rio	345	tons	50%	155	3,264
Deer Valley	425	tons	75%	96	2,008
19th Avenue	1,007	tons	85%	136	2,856
SR-85	--	tons	--	--	--
Total	**13,524**	**tons**	**70%**	**3,645**	**76,537**

***The GHG emissions are calculations by multiplying the Net Methane Release by the GWP for methane (21). The calculations show above include variations due to rounding in the supporting document spreadsheets.**

To ensure the accuracy of the landfill emissions, city staff provided LandGEM model results for the landfills. The EPA model uses First Order Decay principles to project emissions based on amount of waste in a landfill. The LandGEM model estimates were compared to records of methane measurements in 2005. The actual measured methane data was approximately 40 percent lower than the LanGem model emission predictions. Therefore, the LandGEM model outputs were reduced by 40 percent for both 2005 and the 2015 methane estimates. This approach complies with the LGOP accounting system which allows adjustments to the modeling predictions based on actual methane emissions data.

2015 Growth Forecast

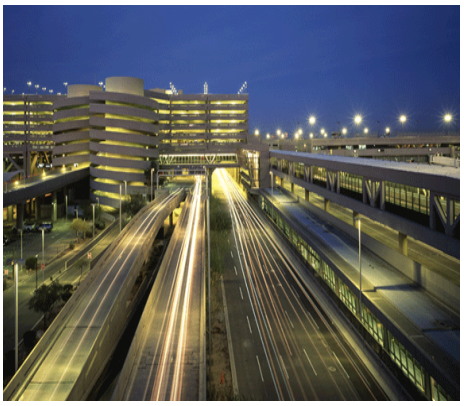
Emissions from the Solid Waste sector are forecast to *decline* to 59,619 metric tons CO2e by 2015 under a No Action scenario. This 16,918 ton change in emissions represents a 22 percent GHG reduction based upon the natural declining methane production in the closed landfills, installation of improved methane collection systems at the Skunk Creek landfill, and opening of the SR-85 landfill in 2006. The specific assumptions are detailed below.

• Declining Methane Production**:** The 2015 emissions reflect the *decline* in methane levels at the landfills based on the natural solid waste decay process.

• Skunk Creek Landfill. The Skunk Creek Landfill was closed in December 2005. In 2006, the final cap was installed and the methane collection system was expanded – resulting in an increase in methane collection efficiency from a baseline of 50 percent in 2005 to 85 percent after installation. The 2015 No Action forecast is based on the incremental improvement in the methane collection efficiency from 50 percent in 2005 to the 75 percent (the industry standard default value from EPA models) in 2015. The additional improvement from 75

percent to the 85 percent methane collection efficiency is included in the Action Plan as a GHG reduction measure.

• SR-85 Landfill. This landfill opened in January 2006 and began accepting the waste that had formerly gone to Skunk Creek. This landfill has an estimated methane collection efficiency of 90 percent. Because this is better than the 75 percent industry standard default value used in the EPA models, the 2015 forecast is based on the incremental improvement in the capture rate efficiency from 50 percent at the Skunk Creek Landfill (the only operating landfill in 2005) to the 75 percent industry standard. The additional improvement from 75 percent to 90 percent is included in the Action Plan as a GHG reduction measure.



6. Employee Commute

This sector includes the emissions resulting from employee commute. Although these emissions are not directly related to city operations, the LGOP accounting system recommends inclusion in the inventory because the city has some ability to impact the activity through rideshare incentives and other programs.

The City of Phoenix employs approximately 17,300 staff with the vast majority in the Police and Fire Departments. To reduce vehicle travel and associated air pollution, the city has an active rideshare program which includes free transit/light rail passes for all employees, reduced parking fees for car/vanpools, and other incentives.

2005 Emissions

The total emissions resulting from employee commute were calculated to be approximately 27,722 metric tons CO_2e in 2005. This equates to 4 percent of total emissions from municipal operations. Table 4 shows the emissions from each vehicle fuel type.

Table 4: EMPLOYEE COMMUTE EMISSIONS BY VEHICLE TYPE

CATEGORY	DISTANCE TRAVELED	GHG EMISSIONS
	Miles in 2005	2005 CO_2e metric tons
Gasoline	53,412,718	27,436
Electric	370,706	54
CNG	370,706	108
LPG	370,706	124
Totals	**54,524,836**	**27,722**

The employee commute data is based on information from the annual survey conducted by the regional rideshare program. The survey determines how many employees drive alone, carpool, take public transportation, walk, bike, or participate in a compressed work week program. The survey also asks if the employee used an alternative fuel (CNG, LPG, or electric). Because the survey does not ask for detail on which alternative fuel is used, the inventory assigned alternative fuel use equally between the three options. The emissions figures listed in the table above only account for emissions from personal vehicles.

2015 Growth Forecast

The GHG emissions from this sector are forecast to increase to 30,622 metric tons CO_2e by 2015 under a No Action scenario. This growth of 2,900 metric tons of CO_2e represents a 10 percent increase over 2005 levels. This is based on an assumption that the number of miles driven by employees in their work related commute will grow at one percent annually between 2005 and 2015.

7. Wastewater Treatment (WWT)

This sector includes GHG emissions from stationary and process emissions at the two WWT facilities operated by the city: the 23rd Avenue and 91st Avenue WWT plants. The WWT process generates CH_4 and N_2O from the incomplete combustion of methane at the flairs, effluent discharge, and the nitrification/denitrification process.

This Section does not include the electricity and natural gas used for WWT because those emissions are documented in the Buildings and Other Facilities sector in Section 3.

As discussed in Section 2 of this report, the emissions from the 91st Avenue WWT plant are included because the City of Phoenix is the primarily responsible for the direct operation of the facility and is listed on the facilities air and water permits. This approach may be subject to change in the future if other partners in the facility develop their own GHG emissions inventories and wish to include their share of the emissions from the facility.

2005 Emissions

The WWT process and fugitive emissions were approximately 15,596 metric tons CO_2e in 2005, or 3 percent of total City of Phoenix government operations emissions. Table 5 shows the breakdown of sources within the WWT sector. The CO_2e emissions are calculated by multiplying each gas by its GWP factor: CH_4 = 21 GWP and N_20 = 310 GWP.

Table 5: 2005 WASTEWATER TREATMENT EMISSIONS BY SOURCE

CATEGORY	CH_4/N_20 PRODUCTION		GHG EMISSIONS
	2005 Methane Production	Units: Metric	2005 CO_2e metric tons*
Stationary CH_4 Emissions from Incomplete Combustion of Digester Gas	31	tons	662
91st Avenue - Process N_20 Emissions from WWTP with Nitrification/Denitrification	12	tons	3,704
23rd Avenue - Process N_20 Emissions from WWTP with Nitrification/Denitrification	3	tons	881
91st Avenue - Process N_20 Emissions from Effluent Discharge (1)	24	tons	7,318
23rd Avenue - Process N_20 Emissions from Effluent Discharge	10	tons	3,031
Totals	**80**	**tons**	**15,596**

* The calculations are of net release multiplied by the global warming potential vary because of rounding in the source data. Emissions are based on LGOP default values for WWT processes.

The N_2O emissions numbers listed above for 91st Avenue WWT do not include the effluent discharge to the Palo Verde Nuclear Power plant because it is transferred in a closed pipeline. Therefore, there are no emissions related to the discharge while the wastewater is under the control of the city.

2015 Growth Forecast

Emissions from this sector are forecast to increase under a No Action scenario to 17,595 metric tons CO_2e by 2015. This 1,999 ton growth represents a 13 percent increase over 2005 levels.

This growth forecast is based on anticipated population growth in the service areas of the 23rd Avenue and 91st Avenue WWT plants. Consistent with the LGOP accounting system, these calculations rely on different forecasting parameters than the energy growth rate because the N_2O and CH_4 emissions are more directly tied to waste volumes, which are a function of population.

8. Summary

The development of this GHG emissions inventory represents the first step in the development of the City of Phoenix Climate Action Plan. The plan focuses on reducing GHG emissions from municipal operations.

The GHG emissions inventory for the city found that municipal operations generated an estimated 618,682 metric tons CO_2e in 2005. Those emissions are forecast to increase to 706,416 metric tons CO_2e by 2015 under a No Action scenario.

Table 6 provides a summary of the GHG emissions from each sector of Phoenix government operations.

Table 6: SUMMARY OF EMISSIONS FROM ALL SECTORS

SECTOR	GHG EMISSIONS			
	2005 CO_2e metric tons	2015 Projected CO_2e metric tons	2005 – 2015 Projected Increase	2005 – 2015 Projected Percent Increase
Buildings and Other Facilities	376,686	444,291	67,605	18%
Vehicles	122,141	154,289	32,148	26%
Wastewater Treatment	15,596	17,595	1,999	13%
Solid Waste	76,537	59,619	-16,918	-22%
Employee Commute	27,722	30,622	2,900	10%
Totals	**618,682**	**706,416**	**87,734**	**14%**

The emissions data from 2005 serve as a baseline for the Climate Action Plan and will be used to measure progress in the future. The city selected 2015 as the goal year. The emission reductions achieved in 2015 must overcome this growth and achieve additional reductions to meet the GHG reduction goal adopted by the City Council in 2008:

Reduce GHG emissions from city operations to 5 percent below the 2005 levels by 2015.

Data Sources

A discussion of data sources and supporting files is found in Appendix A.

The emissions inventory data files also include a worksheet that estimates the GHG reduction expected for each of the measures in the Climate Action Plan and estimates the total reduction to be achieved by 2015.

Appendix A: Data Source Files

Conducting a greenhouse gas inventory is a very data-intensive process. In order for the inventory results to be easily verified and replicated, a thorough accounting of sources is necessary. This emissions inventory report is supported by a wide range of data records which are summarized in the Emissions Summary Workbook. In addition, ten other Excel workbooks contain the original data on energy use, landfill gas modeling and other details necessary for this comprehensive analysis of GHG emissions.

Emissions Summary: The *Emissions Summary Workbook* is a summary of all inventory data. This Excel-based workbook contains a series of worksheets, as listed in the table below. There is a summary worksheet for each major emissions sector in the inventory.

The individual worksheets (tabs) in the *Emissions Summary Workbook* are listed in Table A.1 below. The key data in each worksheet is directly linked to a cell in its respective source file. Therefore, to find the data source for any entry on a worksheet, simply "click" on that cell and the source cell within the original data file will be displayed in the formula bar.

Table A.1
2005 Government Operations Emissions Summary Workbook – Information Available

Worksheet Name:	Description:
Table of Contents	Overview of the workbook – includes hyperlinks to each worksheet
Growth – Measures – Goal	GHG emissions from each sector in 2005 and 2015, a list of measures in the Action Plan with the estimated emission reduction from each measure, and total GHG reduction expected by 2015.
LGOP Report	Emissions arranged by Scope – based on LGOP accounting.
Buildings and Other Facilities	Energy and GHG data on buildings, streetlights, traffic signals, water delivery, and WWT.
Vehicles	Data on vehicle fuel consumption and related GHG emissions. Includes gasoline, diesel, CNG, LNG, LPG, and aviation fuel.
Wastewater Treatment	CH_4 and N_2O emissions resulting from WWT processes. (Energy for the WWT process is found in the Buildings and Facilities Tab.)
Solid Waste	Methane released from landfills.
Employee Commute	Emissions from employee vehicle travel to and from work.
Emissions Factors	Emission factors and other formulas used to calculate CO_2e emissions.
Measures	Summary of GHG reduction measures and CO_2e impact in 2015.

Data Source Files: The data sources files contain the original, "raw" data as provided by city staff from several departments. Many of these original datasheets are located in the "City of Phoenix Raw Data Summary File.xls" but others are stand-alone worksheets. Table A.2 below lists all the source files that fed into the final inventory as summarized in the Inventory Summary Workbook.

Table A.2: 2005 Inventory Data Sources by Sector

Sector:	Workbook Name:	Worksheet Name (Tabs):
Buildings and Other Facilities	Electricity Summary 2005.xls	n/a
	Natural Gas Summary 2005.xls	n/a
	Southwest Gas Accounts 2005.xls	n/a
	Water Services Energy Use Breakdowns.xls	WSD Energy Data in KW
	Raw Data Summary File.xls	Signal & Light 2005
Vehicles	Raw Data Summary File.xls	Vehicle Fleet Summary 2005
		PD Fuel Cards
		Transit
		Sludge Hauling
		Garbage Collection
	Vehicle Fuel Use 2005.xls	n/a
Wastewater Treatment	Wastewater Treatment Emissions.xls	n/a
Solid Waste	Landfill Gas Emissions Reduction Calculations.xls	n/a
Employee Commute	Raw Data Summary File.xls	Employee Commute Summary 2005

LGOP Accounting and Inventory Updates: As discussed in Section 2 of this report, the calculations in the emissions inventory are consistent with the LGOP accounting principles. This protocol was first released late in 2008 and is subject to regular updates. Future emissions inventory updates will rely on the most recent version of the LGOP. While changes in recommended methodologies may occur in the future, the level of transparency with which this inventory has been developed will make it much easier to account for those changes.

Appendix B: Local Government Operations Protocol (LGOP) Report

As discussed in Section 2, the LGOP accounting system defines major sectors which represent the types of activities that generate emissions; buildings & facilities, fleets, etc. This emissions inventory for the City of Phoenix is organized by sector.

The LGOP also defines three scopes for organizing GHG emissions based on whether they are emitted directly by the reporting entity or indirectly from the generation of electricity etc. Table B.1, provides a profile of the city as well as a presentation of the GHG emissions data organized by scope (rather than by sector).

Table B.1 Local Government Operations Standard Inventory Report

1. Local Government Profile

Jurisdiction Name:	City of Phoenix
Street Address:	200 West Washington Street
City, State, ZIP, Country:	Phoenix, AZ, 85003
Website Address:	www.phoenix.gov
Size (sq. miles):	517
Population:	1,552,259
Annual Budget:	$3.7 Billion (FY2009/10)
Employees (Full Time Equivalent):	17,300
Climate Zone:	Zone 9
Annual Heating Degree Days:	1,350 (Measure of energy demand)
Annual Cooling Degree Days:	4,162 (Measure of energy demand)
City GHG Inventory Contact:	Gaye Knight, MPA, MT
Title:	Project Manager
Department:	Office of Environmental Programs
Email:	gaye.knight@phoenix.gov
Phone Number:	602-256-5669

City Services Provided:

✓	Airport		Natural Gas Utility	✓	Stadiums / Sports Arena
✓	Convention Center	✓	Police	✓	Street Lighting & Traffic Signals
	Electrical Utility		Schools – Primary / Secondary	✓	Water Distribution
✓	Fire Protection		Schools – Colleges/Universities	✓	Water Treatment
	Hospitals		Natural Gas Utility	✓	Wastewater Collection
	Marina		Seaport	✓	Wastewater Treatment
✓	Mass Transit - Buses	✓	Solid Waste Collection		
	Mass Transit – Ferries	✓	Solid Waste Disposal		
✓	Mass Transit – Light Rail				

2. GHG Inventory Details

Reporting Year: 2005
Protocol Used: Local Government Operations Protocol, Version 1.0 (September 2008)
Control Approach: Operational Control

GHG Emissions Summary (All Units in Metric Tons Unless Stated Otherwise)

Note: CO_2e totals listed here are summed totals of the estimated emissions of each inventoried gas based upon their global warming potentials (Appendix E of LGOP)

BUILDINGS & OTHER FACILITIES

SCOPE 1	CO_2e	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6
Stationary Combustion – Natural Gas*	6,397	6,380	0.6	0.0			
Fugitive Emissions	0.0	0.0	0.0	0.0			
Total Direct Emissions: Buildings & Facilities	6,397	6,380	0.6	0.0	0.0	0.0	0.0

SCOPE 2	CO_2e	CO_2	CH_4	N_2O
Purchased Electricity	176,425	175,718	2.5	2.1
Purchased Steam				
District Heating & Cooling				
Total Indirect Emissions: Buildings & Facilities	176,425	175,718	2.5	2.1

SCOPE 3: See list at bottom for examples	CO_2e
	0.0

* The natural gas and electricity for wastewater and water processing is not included here. That information is found in the Water and WWT sections below.

STREETLIGHTS AND TRAFFIC SIGNALS

SCOPE 2	CO_2e	CO_2	CH_4	N_2O
Purchased Electricity	44,224	44,047	0.6	0.5
Total Indirect Emissions: Streetlights & Traffic Signals	44,224	44,047	0.6	0.5

SCOPE 3: See list at bottom for examples	CO_2e
	0.0

WATER DELIVERY FACILITIES

SCOPE 1	CO_2e	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6
Stationary Combustion - Natural Gas	98	98	0.1	0.0			
Total Direct Emissions: Water Delivery Facilities	98	98	0.1	0.0	0.0	0.0	0.0

SCOPE 2	CO_2e	CO_2	CH_4	N_2O
Purchased Electricity	63,604	63,350	0.9	0.8
Purchased Steam				
District Heating & Cooling				
Total Indirect Emissions: Water Delivery Facilities	63,604	63,350	0.9	0.8

SCOPE 3: See list at bottom for examples	CO_2e
	0.0

WASTEWATER FACILITIES

SCOPE 1	CO_2e	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6
Stationary Combustion: Natural Gas & Digester Gas	1,591	928	31.5	0.0			
Fugitive Emissions	0.0	0.0	0.0	0.0			
Process Emissions	14,935			48.2			
Total Direct Emissions: Wastewater Facilities	16,526	928	31.5	48.2	0.0	0.0	0.0

SCOPE 2	CO_2e	CO_2	CH_4	N_2O
Purchased Electricity	85,007	84,668	1.2	1.0
Purchased Steam				
District Heating & Cooling				
Total Indirect Emissions: Wastewater Facilities	85,007	84,668	1.2	1.0

SCOPE 3: See list at bottom for examples	CO_2e
	0.0

Because GHG emissions from energy use is reported here by scope, the electricity and natural gas used to operate the WWT facilities will appear differently from the numbers listed in the Emissions Inventory Report. The Scope 1 emissions from Stationary Combustion includes 661 metric tons of CO_2e from incomplete combustion of digester gas, as well as 930 metric tons of CO_2e from combustion of natural gas in wastewater treatment facilities. By comparison, the WWT data in the Emissions Inventory Report show a total of 15,596 CO2e metric tons which includes 661 tons from natural gas (included in stationary combustion figure) plus 14,935 tons of CO_2e from N_2O production. The detail is available in the *Emissions Summary Workbook.* Process and fugitive emissions are based on LGOP default values.

SOLID WASTE FACILITIES

SCOPE 1	CO_2e	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6
Stationary Combustion	0.0	0.0	0.0	0.0			
Fugitive Emissions	76,537		3,645				
Total Direct Emissions: Solid Waste Facilities	76,537	0.0	0.0	0.0	0.0	0.0	0.0

SCOPE 2	CO_2e	CO_2	CH_4	N_2O
Purchased Electricity				
Purchased Steam				
District Heating & Cooling				
Total Indirect Emissions: Solid Waste Facilities	0.0	0.0	0.0	0.0

SCOPE 3: See list at bottom for examples	CO_2e
	0.0

VEHICLE FLEET

SCOPE 1	CO_2e	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6
Mobile Combustion	122,141	120,530	13.5	4.3			
Fugitive Emissions	0.0	0.0	0.0	0.0			
Total Direct Emissions: Vehicle Fleet	122,141	120,530	13.5	4.3	0.0	0.0	0.0

SCOPE 2	CO_2e	CO_2	CH_4	N_2O
Purchased Electricity for Electric Vehicles	0.0	0.0	0.0	0.0
Total Indirect Emissions: Vehicle Fleet	0.0	0.0	0.0	0.0

SCOPE 3: See list at bottom for examples	CO_2e
	0.0

EMPLOYEE COMMUTE

SCOPE 3	CO_2e
Mobile Combustion	27,722

INFORMATION ITEMS

	CO_2e
Information Items1	0.0
Total Information Items	0.0

Total Emissions

	CO_2e	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6
SCOPE 1	221,700	127,936	3,690	26.0	0.0	0.0	0.0
SCOPE 2	369,261	367,783	5.3	4.4	0.0	0.0	0.0
SCOPE 3	27,722						
INFORMATION ITEMS	0						
TOTAL	**618,683**						

Appendix C: Criteria Air Pollutants

In addition to producing greenhouse gas emissions, the combustion of fossil fuels releases other air pollutants. These commonly found air pollutants (also known as "criteria pollutants") are regulated by EPA under the Clean Air Act. EPA has established national ambient air quality standard for these pollutants to protect human health and the environment. The Phoenix urban area does not meet the health standard for PM-10 or the new 2008 standard for Ozone.

The ICLEI Clean Air and Climate Protection Software (CACPS) calculates quantities of nitrogen oxides (NOx), sulfur oxides (SOx), carbon monoxide (CO), volatile organic compounds (VOCs), and particulate matter (PM10). The primary pollutants of concern for ozone are NOx and VOCs. The air pollutants emissions listed below are based on activity data (fuel use, electricity consumption, etc) multiplied by an EPA emission factor. The emission factors are listed in the LGOP protocol.

Table C.1 includes criteria air pollutants resulting from the Buildings and Other Facilities Vehicles, and Employee Commute sectors. Other sectors, such as solid waste or wastewater treatment process emissions, are also potential sources of criteria air pollutant emissions. However, the CACP does not include calculation tools for these sectors, so those emissions are not included below. Data on those emissions may be available from the air quality permit records.

Table C.1 – CRITERIA AIR POLLUTANT EMISSIONS IN 2005

	NOx (metric tons)	SOx (metric tons)	CO (metric tons)	VOC (metric tons)	PM10 (metric tons)
Buildings & Other Facilities	997	2,507	92	11	78
Vehicle Fleet	465	20	1,327	150	17
Employee Commute	78	5	883	91	2
Totals:	**1,540**	**2,532**	**2,302**	**252**	**97**

The total criteria air pollutant emissions in 2005 were 6,723 metric tons. A comparison of the sources of criteria pollutants shows that the energy use in buildings and other facilities was the largest - with 55 percent of the total emissions. The vehicle fleet sector was responsible for 29 percent and employee commute for 16 percent.

A review of the relative contribution of each of the criteria pollutants shows that the emissions of SOx were the highest (38 percent), followed by CO (34 percent), NOx (23 percent), VOC (4 percent), and PM10 (1 percent).

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